ELECTROPHORETIC DISPLAY AND PROCESS FOR ITS MANUFACTURE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a divisional application of U.S. application Ser. No. 10/351,460, filed Jan. 24, 2003; which is a continuation-in-part of U.S. Ser. No. 09/518,488, now U.S. Pat. No. 6,930,818, filed Mar. 3, 2000; the contents of both are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

a) Field of the Invention

This invention is directed to electrophoretic displays and semi-finished display panels comprising display cells prepared from the microcup and top-sealing technologies.

b) Description of Related Art

The electrophoretic display is a non-emissive device based on the electrophoresis phenomenon of charged pigment particles suspended in a solvent. It was first proposed in 1969. The display usually comprises two plates with electrodes placed opposing each other, separated by using spacers. One of the electrodes is usually transparent. A suspension composed of a colored solvent and charged pigment particles is enclosed between the two plates. When a voltage difference is imposed between the two electrodes, the pigment particles migrate to one side and then either the color of the pigment or the color of the solvent can be seen according to the polarity of the voltage difference.

In order to prevent undesired movement of the particles, such as sedimentation, partitions between the two electrodes were proposed for dividing the space into smaller cells. However, in the case of partition-type electrophoretic displays, some difficulties were encountered in the formation of the partitions and the process of enclosing the suspension. Furthermore, it was also difficult to keep different colors of suspensions separate from each other in the partition-type electrophoretic display.

Subsequently, attempts were made to enclose the suspension in microcapsules. U.S. Pat. Nos. 5,961,804 and 5,930,026 describe microencapsulated electrophoretic displays. The microcapsule-based display has a substantially two dimensional arrangement of microcapsules each having therein an electrophoretic composition of a dielectric fluid and a suspension of charged pigment particles that visually contrast with the dielectric solvent. The microcapsules can be formed by interfacial polymerization, in-situ polymerization or other known methods such as physical processes, in-liquid curing or simple/complex coacervation. The microcapsules, after their formation, may be injected into a cell housing two spaced-apart electrodes, or "printed" into or coated on a transparent conductor film. The microcapsules may also be immobilized within a transparent matrix or binder that is itself sandwiched between the two electrodes.

The electrophoretic displays, in particular those prepared according to the processes as disclosed in U.S. Pat. Nos. 5,930,026, 5,961,804, and 6,017,584, have many shortcomings. For example, the electrophoretic display manufactured by the microencapsulation process suffers from sensitivity to environmental changes (in particular sensitivity to moisture and temperature) due to the wall chemistry of the microcapsules. Secondly, the electrophoretic display based on the microcapsules has poor scratch resistance due to the thin wall and large particle size of the microcapsules. To improve the handleability of the display, microcapsules are embedded in a large quantity of polymer matrix which results in a slow response time due to the large distance between the two electrodes and a low contrast ratio due to the low payload of pigment particles. It is also difficult to increase the surface charge density on the pigment particles because charge-controlling agents tend to diffuse to the water/oil interface during the microencapsulation process. The low charge density or zeta potential of the pigment particles in the microcapsules also results in a slow response rate. Furthermore, because of the large particle size and broad size distribution of the microcapsules, the electrophoretic display of this type has poor resolution and addressability for color applications.

SUMMARY OF THE INVENTION

One aspect of the present invention is directed to an array of filled and top-sealed display cells of well-defined shape, size and aspect ratio. The cells are filled with an electrophoretic fluid comprising charged particles dispersed in a dielectric solvent and are individually top-sealed with a polymeric sealing layer. The term "top-seal" is intended to refer to a sealing process in which the display fluid is filled and top-sealed in the display cells constructed on a first substrate or electrode layer. In the edge sealing process typically used for display assembling, two substrates or electrode layers and an edge seal adhesive are required to enclose and edge-seal the display fluid in the cell(s). In contrast, in the top-sealing process, the display fluid is enclosed and top-sealed before a second substrate or electrode layer is disposed on to the display cell(s). The polymeric top-sealing layer is preferably formed from a composition comprising a thermoset or thermoplastic precursor.

Another aspect of the invention is directed to an electrophoretic display comprising an array of filled and top-sealed cells sandwiched between two conductor layers or between one conductor layer and one substrate layer.

A further aspect of the invention is directed to a semi-finished display panel comprising an array of filled and top-sealed cells sandwiched between a temporary substrate such as a release liner and a conductor layer, between a temporary substrate and a permanent substrate layer or between two temporary substrates.

For the electrophoretic display, the display cells are top-sealed before the second conductor or substrate layer is assembled onto the display. For the semi-finished display panel, the display cells are top-sealed before the second temporary substrate, conductor layer or permanent substrate layer is assembled onto the display.

Yet a further aspect of the invention relates to a novel process for the manufacture of an electrophoretic display.

Yet a further aspect of the invention is directed to a novel process for the manufacture of a semi-finished display panel.

Yet a further aspect of the invention is directed to a process for converting a semi-finished display panel to an electrophoretic display.

Yet a further aspect of the invention relates to the preparation of display cells of well-defined shape, size and aspect ratio. The cells enclose a suspension of charged pigment particles dispersed in a dielectric solvent and are formed from microcups prepared according to the present invention. Briefly, the process for the preparation of the microcups involves embossing a thermoplastic or thermoset precursor layer coated on a conductor film with a pre-patterned male mold, followed by releasing the mold during or after the thermoplastic or thermoset precursor layer is hardened by radiation, cooling, solvent evaporation or other means.